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(72) Inventors; and

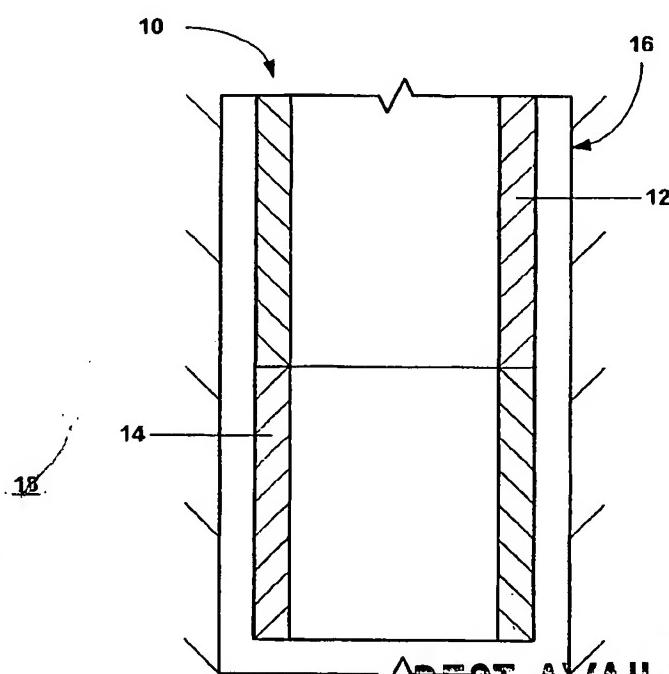
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(54) Title: EXPANDABLE TUBULAR



(57) Abstract: A system for reducing the coefficient of friction between an expansion device and the tubular member during radial expansion.

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AMENDED CLAIMS

received by the International Bureau on 24 October 2005 (24.10.2005) : original claims 1-1369 have been replaced by amended claims 1-1369.

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925. (Original) An expansion device for radially expanding and plastically deforming the tubular member, comprising:

one or more expansion surfaces on the expansion device for engaging the interior surface of the tubular member during the radial expansion and plastic deformation of the tubular member; and

a lubrication device operably coupled to the expansion surface for injecting lubricant into an interface between the expansion surface and the tubular member during the radial expansion and plastic deformation of the tubular member when a predetermined pressure for lubrication is reached.

926. (Original) The expansion device of claim 925, wherein the lubrication device comprises a pump.

927. (Original) The expansion device of claim 925, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant; and
a means for injecting the lubricant in the reservoir into the interface when the predetermine pressure is reached.

928. (Original) The expansion device of claim 925, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant;
a valve fluidicly coupled to the reservoir and the expansion surface for injecting the lubricant into the interface when the predetermine pressure is reached.

929. (Original) The expansion device of claim 925, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant;
a pressure enhancer operably coupled to the reservoir to increase the pressure on the lubricant in the reservoir; and
a valve fluidicly coupled to the reservoir and the expansion surface for injecting the lubricant into the interface when the predetermine pressure is reached.

930. (Original) The expansion device of claim 925, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant;
a piston operably coupled to the reservoir; and
a valve fluidicly coupled to the reservoir and the expansion surface for injecting the lubricant into the interface when the predetermine pressure is reached.

931. (Original) The expansion device of claim 925, wherein the coefficient of friction between the expansion device and the tubular member during radial expansion and plastic deformation is less than 0.08.

932. (Original) The expansion device of claim 925, wherein the coefficient of friction between the expansion device and the tubular member during radial expansion and plastic deformation is in the range of .02 to 0.05.

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949. (Original) The expansion device of claim 925, additionally comprising
a coating on the expansion device prior to positioning within the tubular member.

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951. (Original) The expansion device of claim 925, additionally comprising
a coating on the tubular member prior to positioning the expansion device within the
tubular member.

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969. (Original) The expansion device of claim 925, additionally comprising:
means for injecting lubricant through at least two portions of the expansion device
between the tubular member and the expansion device at two different
pressures.

970. (Original) The expansion device of claim 925, wherein the expansion device,
comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 30 degrees and the expansion
surfaces are located on the tapered portion.

971. (Original) The expansion device of claim 925, wherein the expansion device,
comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;

wherein the sliding angle is less than or equal to 10 degrees and the expansion surfaces are located on the tapered portion.

972. (Original) The expansion device of claim 925, wherein the lubricant comprises at least nine components selected from the group consisting of:

a base oil; metal deactivator; antioxidants; sulfurized natural oils; phosphate ester; phosphoric acid; viscosity modifier; pour-point depressant; defoamer; and carboxylic acid soaps.

973. (Original) The expansion device of claim 925, wherein the expansion device, comprises:

a tapered portion having a tapered faceted polygonal outer expansion surface.

974. (Original) The expansion device of claim 925, wherein the tubular member has a non-uniform wall thickness and the expansion device comprises:

a tapered portion having a tapered faceted polygonal outer expansion surface.

975. (Original) The expansion device of claim 925, wherein lubricant is stored in a reservoir with electrodes that are electrically coupled a capacitor in the expansion device and is injected through at least a portion of the expansion device between the tubular member and the expansion device when the capacitors discharges.

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980. (Original) A method for radially expanding and plastically deforming the tubular member, comprising:

positioning an expansion device having one or more expansion surfaces in the interior surface of the tubular member;

displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and

operating a lubrication device to inject lubricant into an interface between the expansion surface and the tubular member when a predetermined lubricant pressure is reached.

981. (Original) The method of claim 980, wherein the a lubrication device comprises a pump.

982. (Original) The method of claim 980, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant; and
a means for injecting the lubricant in the reservoir into the interface when the predetermine pressure is reached.

983. (Original) The method of claim 980, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant; and
a valve fluidicly coupled to the reservoir and the expansion surface for injecting the lubricant into the interface when the predetermine pressure is reached.

984. (Original) The method of claim 980, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant;
a pressure enhancer operably coupled to the reservoir to increase the pressure on the lubricant in the reservoir; and
a valve fluidicly coupled to the reservoir and the expansion surface for injecting the lubricant into the interface when the predetermine pressure is reached.

985. (Original) The method of claim 980, wherein the lubrication device comprises:
a reservoir operably coupled to the expansion surface for house a lubricant;
a means for pressurizing the lubricant;
a piston operably coupled to the reservoir; and
a valve fluidicly coupled to the reservoir and the expansion surface for injecting the lubricant into the interface when the predetermine pressure is reached.

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1004. (Original) The method of claim 980, additionally comprising
coating on the expansion device prior to positioning within the tubular member.

1005. (Canceled)

1006. (Original) The method of claim 980, additionally comprising
coating the tubular member prior to positioning the expansion device within the
tubular member.

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1022. (Original) The method of claim 980, wherein the expansion device comprises a relatively smooth surface roughness and includes relatively evenly spaced oil pockets.

1023. (Canceled)

1024. (Original) The method of claim 980, additionally comprising:
injecting lubricant through at least two portions of the expansion device between the tubular member and the expansion device at two different pressures.

1025. (Original) The method of claim 980, wherein the expansion device, comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion;
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 30 degrees and the expansion
surfaces are located on the tapered portion.

1026. (Original) The method of claim 980, wherein the expansion device, comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion;
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 10 degrees and the expansion
surfaces are located on the tapered portion.

1027. (Original) The method of claim 980, wherein the lubricant comprises at least
nine components selected from the group consisting of:
a base oil; metal deactivator; antioxidants; sulfurized natural oils; phosphate
ester; phosphoric acid; viscosity modifier; pour-point depressant;
defoamer; and carboxylic acid soaps.

1028. (Original) The method of claim 980, wherein the expansion device, comprises:

a tapered portion having a tapered faceted polygonal outer expansion surface.

1029. (Original) The method of claim 980, wherein the tubular member has a non-uniform wall thickness and the expansion device comprises:

a tapered portion having a tapered faceted polygonal outer expansion surface.

1030. (Original) The method of claim 980, wherein lubricant is stored in a reservoir with electrodes that are electrically coupled a capacitor in the expansion device; additionally comprising:

charging the capacitor;

discharging the capacitor through the electrodes; and

injecting the lubricant through at least a portion of the expansion device between the tubular member and the expansion device when the capacitors discharges.

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1036. (Original) The lubricant delivery assembly of claim 911, wherein the lubricant injection mechanism is a valve and the lubricant is drilling fluid received in the reservoir.

1037. (Original) The lubricant delivery assembly of claim 911, wherein the reservoir is fluidically connected to drilling fluid used to expand the tubular member,
the lubricant injection mechanism, comprising

a pressure accelerator received within the reservoir that separates the drilling fluid and the media.

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1044. (Original) A method of reducing the coefficient of friction between the expansion device and the tubular member during radial expansion to less than 0.08, comprising:

altering at least one of the elements selected from the group consisting of: expansion device geometry, expansion device composition, expansion device surface roughness, expansion device texture, expansion device coating, lubricant composition, lubricant environmental issues, lubricant frictional modifiers, tubular member roughness, and tubular member coating.

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1046. (Original) A lubrication system for lubricating an interface between a first element and a second element, comprising:

a vaporizer proximate to the interface for vaporizing a lubricant to inject the lubricant in the interface.

1047. (Original) The system of claim 1046, wherein the first element comprises an expansion device and the second element comprises tubular member during radial expansion and plastic deformation of the tubular member.

1048. (Original) The lubrication system of claim 1046, wherein the vaporizer comprises:

a reservoir for housing a lubricant; and
an electric pulse generator to create an electric pulse in the lubricant.

1049. (Original) The lubrication system of claim 1048, wherein the electric impulse generator comprises:

at least two electrodes housed in the reservoir; and
at least one capacitor electrically coupled to the electrode.

1051. (Original) The lubrication system of claim 1046, wherein the vaporizer comprises:

a reservoir for housing a lubricant; and
an magnetic pulse generator to create a magnetic pulse in the lubricant.

1052. (Original) The lubrication system of claim 1051, wherein the electric impulse generator comprises:

magnetic coil housed in the reservoir.

1053. (Original) The lubrication system of claim 1046, wherein the lubrication system additionally comprises:

an expansion device for positioning in a tubular member; and
wherein the coefficient of friction between the expansion device and the tubular member during radial expansion and plastic deformation is less than 0.08.

1054. (Original) The lubrication system of claim 1053, wherein the coefficient of friction is in the range of .02 to 0.05.

1055. (Original) The lubrication system of claim 1053, additionally comprising:
lubricant between the tubular member and the expansion device.

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1093. (Original) The lubrication system of claim 1053, wherein lubricant is injected through at least a portion of the expansion device between the tubular member and the expansion device.

1094. (Original) The lubrication system of claim 1053, wherein lubricant is injected through at least a portion of the expansion device between the tubular member and the expansion device when a predetermined lubricant pressure is met.

1095. (Original) The lubrication system of claim 1053, wherein lubricant is injected through at least two portions of the expansion device between the tubular member and the expansion device at two different pressures.

1096. (Original) The lubrication system of claim 1053, wherein the expansion device comprises:

a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 30 degrees.

1097. (Original) The lubrication system of claim 1053, wherein the expansion device comprises:

a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 10 degrees.

1098. (Original) The lubrication system of claim 1053, additionally comprising
lubricant between the tubular member and the expansion device, comprising at least
nine components selected from the group consisting of:
a base oil; metal deactivator; antioxidants; sulfurized natural oils; phosphate
ester; phosphoric acid; viscosity modifier; pour-point depressant;
defoamer; and carboxylic acid soaps.

1099. (Original) The lubrication system of claim 1053, wherein the expansion device comprises:

a tapered portion having a tapered faceted polygonal outer expansion surface.

1100. (Original) The lubrication system of claim 1053, wherein the tubular member has a non-uniform wall thickness and the expansion device comprises:
a tapered portion having a tapered faceted polygonal outer expansion surface.

1101. (Original) The lubrication system of claim 1053, wherein at least one capacitor comprises a capacitor bank.

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1107. (Original) A method for lubricating an interface between a first element and a second element, comprising:
vaporizing a lubricant proximate to the interface to inject the lubricant in the interface.

1108. (Original) The method of claim 1107, wherein the first element comprises an expansion device and the second element comprises tubular member during radial expansion and plastic deformation of the tubular member.

1109. (Original) The method of claim 1107, additionally comprising:
housing a lubricant in a reservoir having an exit passageway; and
generating an electric pulse in the reservoir, thereby vaporizing the lubricant and causing a pressure pulse to force lubricant out of the exit passageway.

1110. (Original) The method of claim 1109, wherein the electric pulse is generated by discharging a capacitor through electrodes stored in the lubricant.

1111. (Original) The method of claim 1107, additionally comprising:
housing a lubricant in a reservoir having an exit passageway; and

generating a magnetic pulse in the reservoir, thereby vaporizing the lubricant and causing a pressure pulse to force lubricant out of the exit passageway.

1112. (Original) The method of claim 1111, wherein the magnetic pulse is generated by current running current through magnetic coils stored in the lubricant.

1113. (Original) A method of claim 1070, additionally comprising:
positioning an expansion device having a first tapered end and a second end at least partially within the tubular member;
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and
wherein the coefficient of friction between the expansion device and the tubular member during radial expansion and plastic deformation is less than 0.08.

1114. (Original) The method of claim 1113, wherein the coefficient of friction is in the range of .02 to 0.05.

1115. (Original) The method of claim 1113, additionally comprising:
injecting lubricant between the tubular member and the expansion device;

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1132. (Original) The method of claim 1113, additionally comprising applying a coating on the expansion device prior to positioning within the tubular member.

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1134. (Original) The method of claim 1113, additionally comprising applying a coating on the tubular member prior to positioning the expansion device within the tubular member.

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1152. (Original) The method of claim 1113, additionally comprising:
 injecting lubricant through at least a portion of the expansion device between the
 tubular member and the expansion device.

1153. (Original) The method of claim 1113, additionally comprising:
 injecting lubricant through at least a portion of the expansion device between the
 tubular member and the expansion device when a predetermined lubricant
 pressure is met.

1154. (Original) The method of claim 1113, additionally comprising:
 injecting lubricant through at least two portions of the expansion device between the
 tubular member and the expansion device at two different pressures.

1155. (Original) The method of claim 1113, wherein the expansion device, comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 30 degrees.

1156. (Original) The method of claim 1113, wherein the expansion device, comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 10 degrees.

1157. (Original) The method of claim 1113, additionally comprising
injecting lubricant between the tubular member and the expansion device, comprising
at least nine components selected from the group consisting of:
a base oil; metal deactivator; antioxidants; sulfurized natural oils; phosphate
ester; phosphoric acid; viscosity modifier; pour-point depressant;
defoamer; and carboxylic acid soaps.

1158. (Original) The method of claim 1113, wherein the expansion device, comprises:
a tapered portion having a tapered faceted polygonal outer expansion surface.

1159. (Original) The method of claim 1113, wherein the tubular member has a non-uniform wall thickness and the expansion device comprises:
a tapered portion having a tapered faceted polygonal outer expansion surface.

1160. (Original) The method of claim 1113, wherein the at least one capacitor
comprises a capacitor bank.

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